

REMARKS

Confirmation of Election

Claims 1 to 58 are pending in the application. The Examiner issued a restriction requirement, finding that the claims are directed to two distinct inventions. Claims 1-34, drawn to a process for copper metallization and Claims 35 to 58, drawn to a diffusion barrier. Applicants provisionally elected Claims 35 to 58 in a conversation with the Examiner on December 20, 2002. Applicants hereby confirm their provisional election.

Request for Clarification

Claims 35-58 are rejected on a variety of grounds. In the Office Action, the Examiner refers to the Lai et al. reference (U.S. Patent No. 6,024,175) in each of the rejections. However, in reviewing the references, it appears that the Examiner is actually referring to McTeer et al. (6,204,179). In particular, the teachings and citations referred to by the Examiner correspond to the McTeer reference and not the Lai reference. For example, with respect to the disclosure of a diffusion barrier comprising a layer of metal nitride in the rejection under 102(e), the Examiner refers to Lai, figure 2, number 4 and column 17, line 64. There is no number 4 in figure 2 of Lai and no column 17. However, when applied to the McTeer reference the disclosure appears to be relevant. Thus, in addressing the rejections, Applicants have made the assumption that the rejections are based on the McTeer reference and not the Lai reference. Applicant's would appreciate confirmation that this assumption was correct.

Claim Rejections Under 35 U.S.C. §102(e)

Claims 35-42 and 45 were rejected under 35 U.S.C. §102(e) as anticipated by McTeer. The Examiner asserted that McTeer discloses a diffusion barrier wherein the grain boundaries of a metal nitride layer are stuffed with a metal compound of the reactive metal. Applicants disagree and respectfully traverse the rejection.

There is no teaching or suggestion in McTeer of grain boundaries of a metal nitride stuffed with a metal compound. The disclosure referred to by the Examiner as teaching stuffed grain boundaries (column 17, lines 45 to 55) teaches annealing of a TiAlN barrier layer in the presence of oxygen. While the anneal may dope the barrier layer with oxygen, it does not stuff

NO
any
metal
nitride
including
Ta, N, W, especially
+ any metal
nitride
includes
Al, Cu, Hf,
V, Nb, Ti

the grain boundaries with a metal compound of a reactive metal, as claimed, as there is no free metal in the TiAlN film to react with the oxygen. While a copper film may subsequently be deposited over the TiAlN barrier layer and annealed, McTeer does not teach that copper stuffs the grain boundaries, as it forms weak bonds with other elements.

In making the rejection, the Examiner also refers to the teaching of a wetting layer of aluminum deposited over the metal nitride barrier layer. However, Claim 35 recites "a layer of metal nitride covered by a layer of reactive metal different from a metal in the metal nitride layer" (emphasis added). Even if the teaching of the aluminum wetting layer is combined with the teaching of an oxygen anneal of a TiAlN layer (and McTeer does not teach this combination), the metal nitride would be covered by a layer of metal that is the same as a metal in the metal nitride layer. Thus, there would still be no teaching or suggestion of the claimed invention.

Further, McTeer clearly states that the purpose of the wetting layer is to make it easier for the copper to reflow and that "the aluminum wetting layer 5 is consumed thereby forming a Cu₃Al alloy layer..." There is no teaching or suggestion that the aluminum from the wetting layer can or does stuff the grain boundaries in a nitride barrier layer.

As McTeer does not teach or suggest a metal nitride layer with stuffed grain boundaries as claimed, Applicants request withdrawal of the rejection of Claims 35-42 and 45.

Although not explicitly stated, it appears that Claims 50-52, 54 and 56-58 were also rejected under 35 U.S.C. §102(e) as anticipated by McTeer.

With respect to Claim 50, the Examiner refers to Figure 9 for the teaching of first and second metal nitride layers with grain boundaries that are stuffed with a different metal compound. However, Figure 9 discloses only a TiAlN layer, a copper layer, and a second TiAlN layer. It does not teach or suggest a layer of reactive metal over the first layer of metal nitride, as claimed. Further, there is no teaching or suggestion that the grain boundaries of either metal nitride layer, much less both metal nitride layers, are stuffed.

With respect to Claim 52, the Examiner found that McTeer teaches a layer of titanium nitride covered by a layer of aluminum, wherein the grain boundaries of the titanium nitride layer are stuffed with aluminum oxide. In particular, the Examiner points to the disclosure of column 17, lines 40 to 57. This disclosure refers to the oxygen anneal of a TiAlN layer. It does not teach a layer of titanium nitride covered by a layer of aluminum, as claimed. Further, it does not teach

that the grain boundaries of the titanium nitride layer are stuffed with aluminum oxide. As discussed above, the disclosure of oxygen doping does not teach or suggest stuffed grain boundaries. As there is no free aluminum in the TiAlN film, there is no aluminum to react with the oxygen in the doped film. Thus, there is no teaching or suggestion of titanium nitride layers stuffed with aluminum oxide.

As the remaining claims in the rejection depend from Claim 50 or 52, Applicants request withdrawal of the rejection of all claims under 35 U.S.C. §102(e) over McTeer.

Claim Rejections Under 35 U.S.C. §103

Claims 43, 44 and 55 are rejected under 35 U.S.C. §103(a) as unpatentable over McTeer as applied in the §102 rejection and further in view of Aoyama et al. (U.S. Patent No. 5,592,024).

Claims 43 and 44 depend from Claim 35. As discussed above, McTeer does not teach or suggest the invention of Claim 35. In particular, it does not teach or suggest a layer of metal nitride covered by a layer of reactive metal different from a metal in the metal nitride layer, wherein the grain boundaries of the metal nitride layer are stuffed with a metal compound of the reactive metal. This deficiency is not made up for by the teaching of Aoyama. Thus, Applicants submit that Claims 43 and 44 are allowable and request withdrawal of the rejection.

With respect to Claim 55, the Examiner refers the teaching of Aoyama at column 19, lines 39-57. This disclosure does not teach or suggest a layer of metal nitride covered by a layer of silicon. Further, there is no teaching or suggestion that the grain boundaries of a metal nitride layer can be stuffed with silicon oxide. Thus, Applicants request withdrawal of this rejection.

Finally, Claim 53 was rejected as unpatentable over the combination of McTeer and Aoyama further in view of Dutta (U.S. 2002/64592). Dutta is referred to for the teaching of atomic layer deposition. Claim 53 depends from Claim 52. As discussed above, there is no teaching or suggestion in McTeer for a diffusion barrier as claimed in Claim 52. This deficiency is not made up for by Aoyama or Dutta. Thus, Applicants request withdrawal of the rejection.

Appl. No. : 10/007,304
Filed : December 5, 2001

Conclusion

For the reasons presented above, Applicants submit that the present claims are patentable over the cited art and are in condition for allowance. If any issues remain, the Examiner is invited to contact Applicants' counsel at the number provided below in order to resolve such issues promptly.

Respectfully submitted,

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Dated: April 28, 2003

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